

## Biogeography of bacterial floras associated with rock tripe and related lichens inhabiting polar, alpine and equatorial regions.

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Microbial biogeography convey information on the distribution of microbial biodiversity over space and time. For decades, the Baas-Becking hypothesis; “everything is everywhere, but the environment selects” has been widely accepted. The hypothesis emphasizes that microorganisms are omnipresent, but in relative uneven compositions, of which some remain undetected. Microbial compositions are influenced by several factors among which environmental condition is one key factor. Only recently, microbial biogeography was accepted, although it is still debated. The current microbial biogeography focuses mostly on free-living microbes, and gradually move on to host-associated microbial biogeography. However, little is known on the biogeography of microbes found associated with symbiotic-host organisms.

Lichens are the oldest known symbiotic organisms which are composed of fungi and photosynthetic partners like algae or cyanobacteria forming thallus. Rock tripe, the common name given to various lichens belonging to the genus *Umbilicaria*, is widely distributed and can be found growing in hostile habitats such as fellfields. Diverse microbes were found associated with rock tripe, however, bacterial flora has been a recent interest due to its proposed functional roles in lichen-symbiosis. Despite reports on rock tripe’s associated bacterial flora, still little is known on the biogeographical distribution of bacterial flora associated with rock tripe and related lichens. This study assessed the biogeographical distribution of bacterial flora associated with rock tripe and related lichens inhabiting the north and south polar regions, as well as equatorial alpine and plateau regions.

A total of 50 morphologically identified rock tripe and related lichen specimens were taken from Arctic and Antarctic locations, Uganda in equatorial Africa, and Guyana in equatorial South America. At the polar regions, 9 specimens were from sites within the Arctic circumpolar, at latitudes 67° to 71°N, and 18 specimens were collected in Antarctic at latitude 69° S. Near equator regions, 11 specimens were taken from the alpine Rwenzori Mountains in Uganda at latitude of 0°, and 12 specimens from the highlands of Guyana at latitude 5° N. Employing Illumina next generation sequencing, hypervariables V3 and V4 of the 16S rRNA genes were sequenced to examine bacterial flora associated with the 50 specimens, data were analyzed using the program QIIME.

The results show that across the total 50 samples, *Acetobacteraceae*, a family in the Class *Alphaproteobacteria* were found in all samples in varying abundances. In samples of Uganda, Guyana and Arctic, *Acetobacteraceae* was prominently observed. This supported previous reports that *alphaproteobacteria* predominantly associated with different species of lichens. The bacterial flora associated with rock tripe in Antarctic were predominated by *Bacteroidetes*, particularly by *Sphingobacteriaceae*. According to phylogenetic tree, bacterial flora of specimens collected at close located sites were closely related to each other than they were to specimens in other regions. For instance, the bacterial flora associated to 12 lichens collected in Guyana were closely related to each other than they were to lichens collected from Uganda, Arctic or Antarctic. When comparing groups of samples based on phylogenetic distance matrix, the bacterial floras showed distinctive groupings among samples from the same regions, although there were few exceptional overlaps between Guyana and Uganda’s bacterial flora groupings.

The *Acetobacteraceae* was found in all 50 specimens, indicating that the *Acetobacteraceae* represents the candidate cosmopolitan bacterial taxon associated with rock tripe and related lichens. This may differ for other lichen species, therefore we are hesitated to assume that this is true for all species of lichens. The distinct groupings into sampling sites could be explained by bacterial floras experiencing similar environmental conditions, hence demonstrating similar bacterial species compositions. Here, biogeographical distributions of bacterial floras associated with rock tripe and related lichens were influence by various factors, and one key factor is the micro- and macro-environment interactions, although cosmopolitan species are generalist that can thrive in diverse environment.

## References

De Wit R, Bouvier T (2006) “Everything is everywhere, but the environment selects”; what did Baas Becking and Beijerinck really say? *Environ Microbiol* 8:755–8.